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Linking synoptic patterns to cloud properties and local circulations over the Houston, TX region

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ARM

Motivation and Objectives

- **Motivation**
  - Provide climatological guidance on cloud properties and the probability of sea-breeze convection for ARM TRACER (Jensen et al., 2019) preparation and forecasting.
  - Quantitatively define periods of similar meteorological conditional towards exploration and isolation of relationships among aerosol populations, environmental conditions and convective properties.

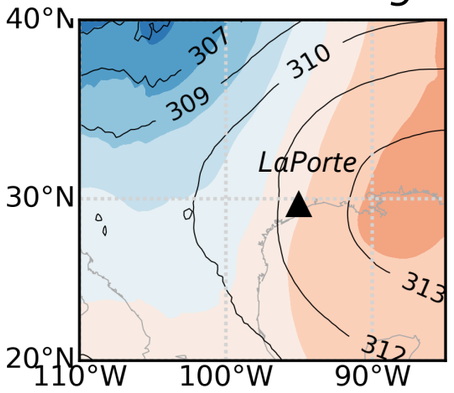
- **Objectives**
  - Classify meteorological regimes over the Houston region using machine learning techniques.
  - Identify regimes that favor sea-breeze convection and sea-breeze circulation.

Regime Classification

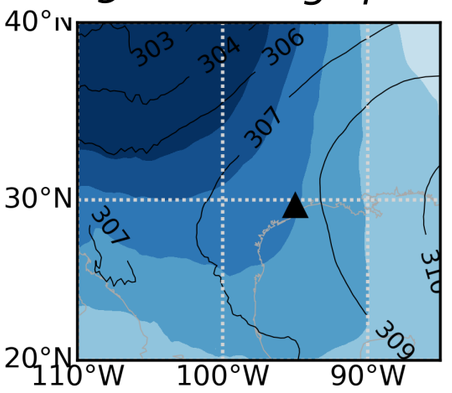
- **Self-Organizing Map (SOM)**
  - An unsupervised machine learning technique that outputs a continuous distribution of synoptic regimes.
  - Open Python package: **MiniSom**, *https://github.com/JustGlowing/minisom*
  - Inputs: 10 years of 700hPa geopotential height anomalies from ERA5 data during summer months (Jun. – Sep.).
  - Outputs: 16 synoptic regimes, including ***4 primary regimes*** and a spectrum of transitional states between those.

Primary regimes

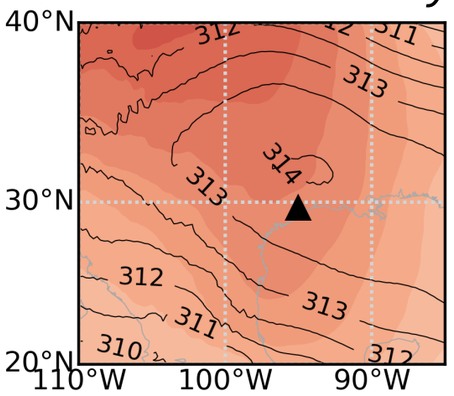
#0: Bermuda High



#3: Pre-trough pattern



#12: Continental anticyclone



#15: Post-trough pattern

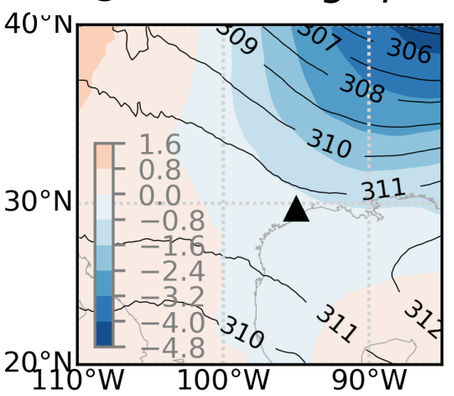


Figure: Composite of 700hPa geopotential heights (contours) and anomalies (colors; reds: positive anomalies; blues: negative anomalies)

Cloud Properties

- **We project satellite and radar datasets onto each regime.**
  - Develop correlations of cloud properties with synoptic patterns.
  - Identify potential sea-breeze regimes.
- **Anticyclone regimes tend to favor sea-breeze circulation.**
  - Bermuda High regimes (#4, #8): increased convection frequency along the coast due to significant moisture advection from the Gulf of Mexico.
  - Continental anticyclone regimes (#12, #13): pronounced sea-breeze circulation but less probability of convection.

Examples of potential sea-breeze regimes

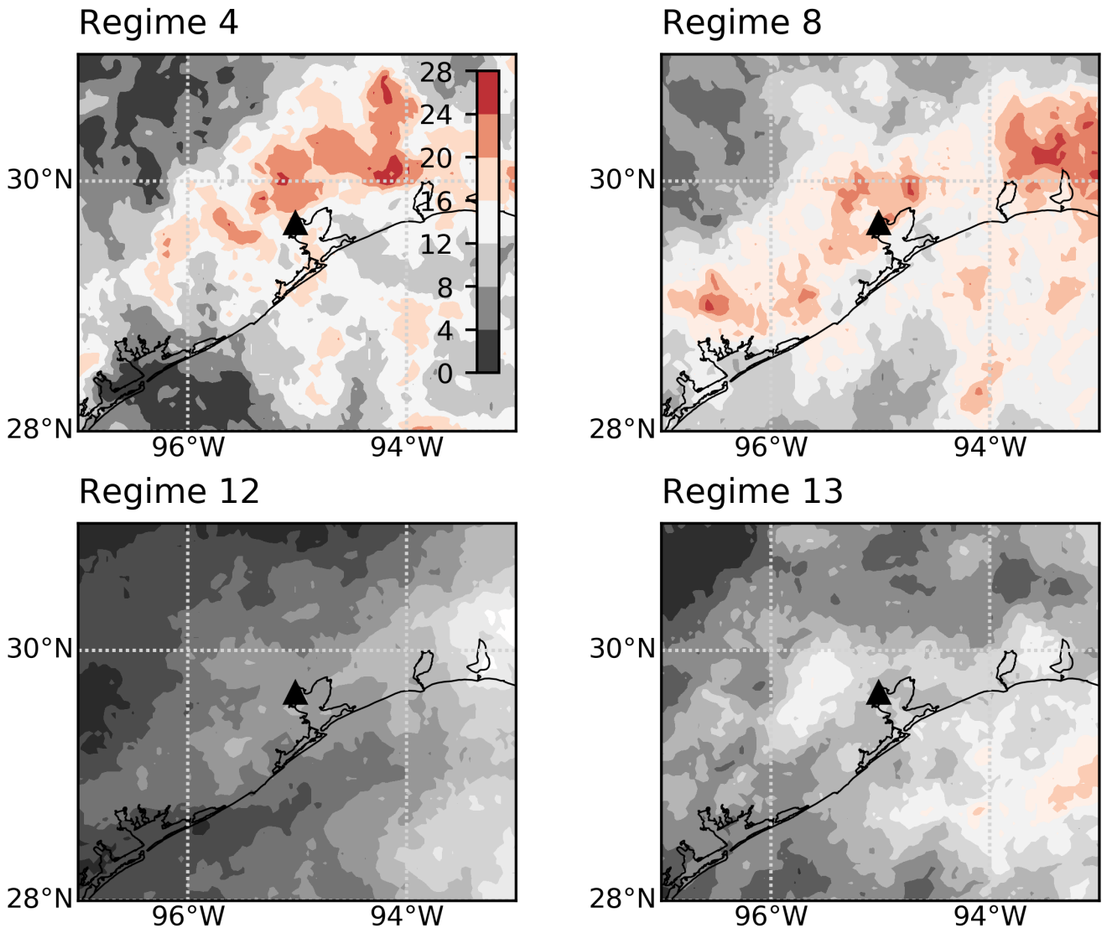


Figure: Percentage of GOES IR brightness temperature < 240 K (deep convective cells) at 19 UTC.

Sea-breeze Convection Regimes

- **Diurnal cycle of convective cell frequency**
  - Sea-breeze convection initiated along the coast and propagates to the inland in the afternoon.

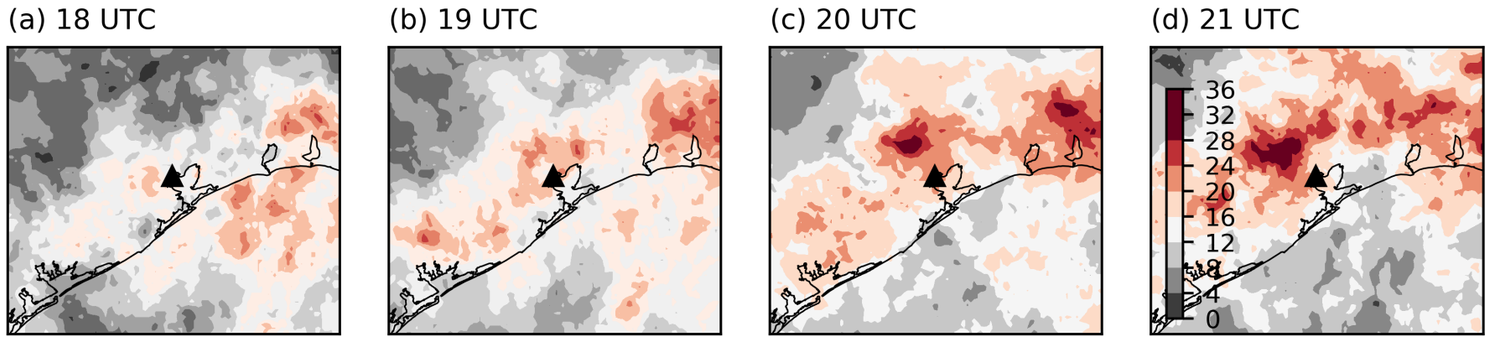


Figure: Percentage of GOES IR brightness temperature < 240 K for potential sea-breeze regime 8.

- **The Texas Commission on Environmental Quality (TCEQ) surface measurements**
  - There is a shift in wind direction and an increase in wind speed in the anticyclone regimes, which confirms a sea/bay-breeze onset.

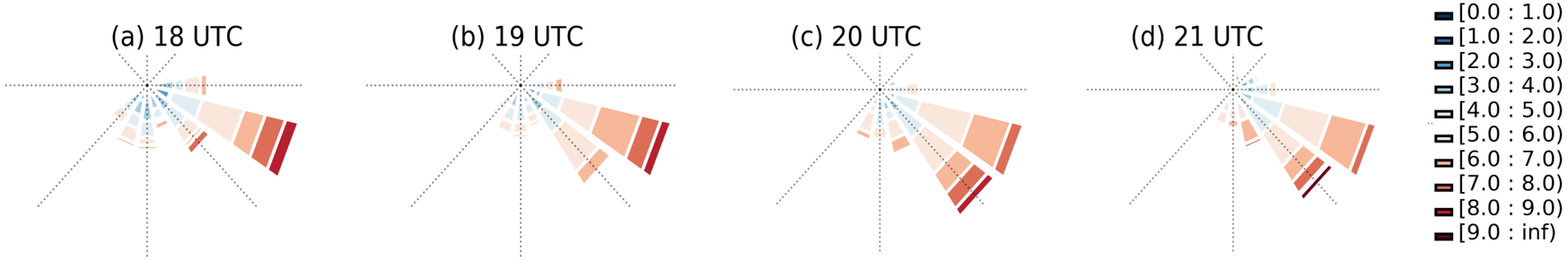


Figure: Windroses for the LaPorte site for regime 8.

Summary

- **Key findings:**
  - Using SOM, we distinguish four primary synoptic regimes for the Houston summertime, with a spectrum of transitional states between those.
  - In the continental and maritime anticyclone regimes, the Houston area is dominated by large-scale subsidence, favoring frequent sea-breeze circulation and sea-breeze convection.
- **Future plans:**
  - Characterizing the convective cell properties as a function of regimes by applying cell tracking techniques.
  - Applying the SOM to TRACER IOPs and explore the relationships in aerosol-convection interactions.